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# DISTRIBUTION, FORAGING BEHAVIOR, AND CAPTURE RESULTS OF THE SPOTTED BAT (*EUDERMA MACULATUM*) IN CENTRAL OREGON

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ABSTRACT.—The spotted bat (*Euderma maculatum*) has been virtually unknown in Oregon despite the existence of potential habitat in many areas of the state. In 2002 and 2003 we searched for spotted bats along the John Day, Deschutes, and Crooked Rivers and at a remote dry canyon southeast of the city of Bend in central Oregon. The species was documented through the use of mist-nets, a bat detector, and recognition of audible spotted bat calls. Spotted bats were found at 11 locations in 6 Oregon counties. Nightly activity patterns of spotted bats were unpredictable. Spotted bats were found in 78% of search areas but on only 48% of survey nights. We observed spotted bats foraging above fields and low upland slopes adjacent to rivers and creeks and along the rims of cliffs. Estimated flying heights of spotted bats ranged from 3 m to 50 m aboveground. The species was difficult to capture and was captured only after considerable experimentation with methods and materials. Three spotted bats were captured toward the end of the project in 2003 and accounted for only 0.5% of all bats captured during the study. Although we attached radio transmitters to 2 spotted bats, we found no roost locations. We believe additional spotted bat surveys in Oregon are warranted, especially in higher-elevation habitats, but recommend that to increase their effectiveness, surveys accommodate the unique foraging behavior of the species.

*Key words: spotted bat,* Euderma maculatum, *distribution, foraging behavior, capture results, Oregon.*

The spotted bat, *Euderma maculatum*, is widespread throughout arid portions of western North America, but it is patchily distributed and only locally common within its range (Fenton et al. 1987, Navo et al. 1992, Pierson and Rainey 1998, Geluso 2000). Unique habitat requirements, namely the presence of large cliffs and water, appear to limit its distribution (Luce 2005). But even within areas of apparently suitable habitat, spotted bats are often absent or infrequently encountered (Geluso 2000). This apparent rarity has prompted most regional and state authorities to list the species either as threatened or of concern (Luce 2005). In Oregon the species has remained largely unknown and the state wildlife agency has not yet assigned it a conservation status (Verts and Carraway 1998, Csuti et al. 2001, Oregon Natural Heritage Program 2001).

Maps of the predicted distribution of the spotted bat have consistently shown central Oregon to be on the periphery of its range (Watkins 1977, Hall 1981, Verts and Carraway 1998, Csuti et al. 2001). However, recent surveys for spotted bats in surrounding states have led to the identification of new localities in habitats similar to those that exist in central Oregon (Sarell and McGuiness 1993, Doering and Keller 1998, Pierson and Rainey 1998, Geluso 2000, Citzen et al. 2001). Approximately two-thirds of the state of Oregon lies east of the Cascade mountain range and contains numerous steeply walled canyons and meadow complexes characteristic of the Intermountain West. These landscapes are typical of spotted bat habitat (e.g., Pierson and Rainey 1998), and the lack of documented spotted bat activity in the region is incongruous with the availability of apparently suitable habitat. Only 2 voucher specimens exist for Oregon, and the only other state records come from 3 isolated reports based on audible detections made during the 1990s along the Snake River on the Oregon border (McMahon et al. 1981, Barss and Forbes 1984, Ormsbee and Risdal 2004).

The most westerly of the historic Oregon records came from a dead specimen found in 1984 in a cliff along the John Day River, but no effort had been made to determine if the species regularly occurred there (Barss and

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Forbes 1984). In July 2002, as part of an ongoing National Park Service (NPS) mammal inventory, we began a search for spotted bats in the John Day River valley. The survey effort continued through October 2003 and was expanded to include areas along the Deschutes and Crooked Rivers west of the John Day Basin and a dry canyon east of the town of Bend, southwest of the Crooked River. The objectives of this study were (1) to determine if spotted bats were present in the historic locality reported by Barss and Forbes (1984), (2) to identify new localities along the John Day River and adjacent drainages, and (3) to capture the species in order to obtain photographic vouchers and information on sex, age, and reproductive condition.

## STUDY AREA

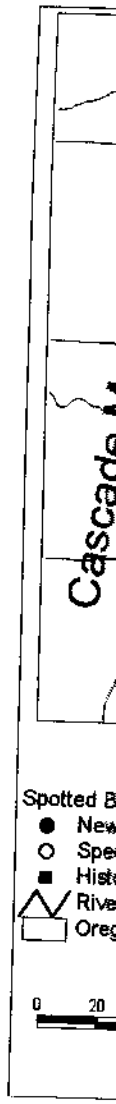
We searched for spotted bats in 14 search areas located along a 290-km section of the John Day River and 3 major tributaries; at selected locations on the Deschutes and Crooked Rivers, a large parallel drainage located to the west of the John Day basin; and at Dry River canyon, 27 km east of the town of Bend, in north central Oregon (see Fig. 1). Our search areas were located near large cliffs and rimrock features in Deschutes, Gilliam, Grant, Jefferson, Wasco, and Wheeler Counties. Along the John Day River, most search areas were concentrated around the 3 widely separated units of the John Day Fossil Beds National Monument (areas 2–9, Table 1). One search area was located at the mouth of a large upland cave 4.5 km off the John Day River (area 7, Table 1). The Dry River search area (area 14, Table 1) was approximately 20 km from the Crooked River, which is a much greater distance from a perennial creek or river than the other 13 search areas. Search area elevations range from 180 m to 1278 m. Elevations of nearby buttes and plateaus range from 1200 m to 1600 m. The climate of the study region is semiarid, dominated by hot, dry summers and cool, dry winters. Mean annual precipitation from weather stations near search areas for the period 1973–2003 ranged from 20 cm to 27 cm (Oregon Climate Service 2003). Juniper-sagebrush steppe vegetation dominates all search areas, except along the narrow riparian zones, where black cottonwood (*Populus trichocarpa*) and willows (*Salix* spp.) are common. Upland steppe vegetation consists of open woodlands of western juniper (*Juniperus occidentalis*), sagebrush (*Artemisia tridentata*), and a variety of annual and perennial grasses. Irrigated agricultural fields or previously cultivated old fields are present along the riverine floodplain terraces and on top of rimrock plateaus near all search areas except the Dry River area (area 14, Table 1).

## METHODS

This study was conducted simultaneously with ongoing mammal inventory work and a telemetry project involving other species of bats in the John Day Fossil Beds National Monument. We conducted surveys in 2002 from 15 July to 10 September. In 2003 they were conducted from 1 May to 18 October. During the course of the study, we visited 24 survey sites, grouped into 14 search areas. Survey site selection was based on suitability for mist-netting and proximity to large cliff complexes. Single visits were made to 11 survey sites, and 13 sites had 2 or more visits made during the study. Survey activities conducted during site visits included mist-netting, recording of echolocation calls, and audiovisual observations of passing spotted bats. Durations of site visits were variable and were dictated by weather and logistical considerations. The average visit was 3.5 hours, with visits ranging from 20 minutes to 9 hours. On some nights we visited more than 1 site. Incidental observations of spotted bats were made while conducting other project activities throughout the study.

Spotted bats produce distinctive echolocation calls audible to the unaided human ear, and the detection of these calls was the primary method of observation (Woodsworth et al. 1981, Leonard and Fenton 1984). Large hand-held spotlights were used in conjunction with audible detections to illuminate spotted bats and to aid in estimating flying height, direction of travel, and other observations of foraging behavior. Each observation was categorized as a "pass," since most observations consisted of bats flying past an observer. Most passes were discrete, unidirectional events, although some events included long periods (e.g., 1–20 minutes) during which individual bats remained within hearing or spotlight distance of an observer. The presence of multiple



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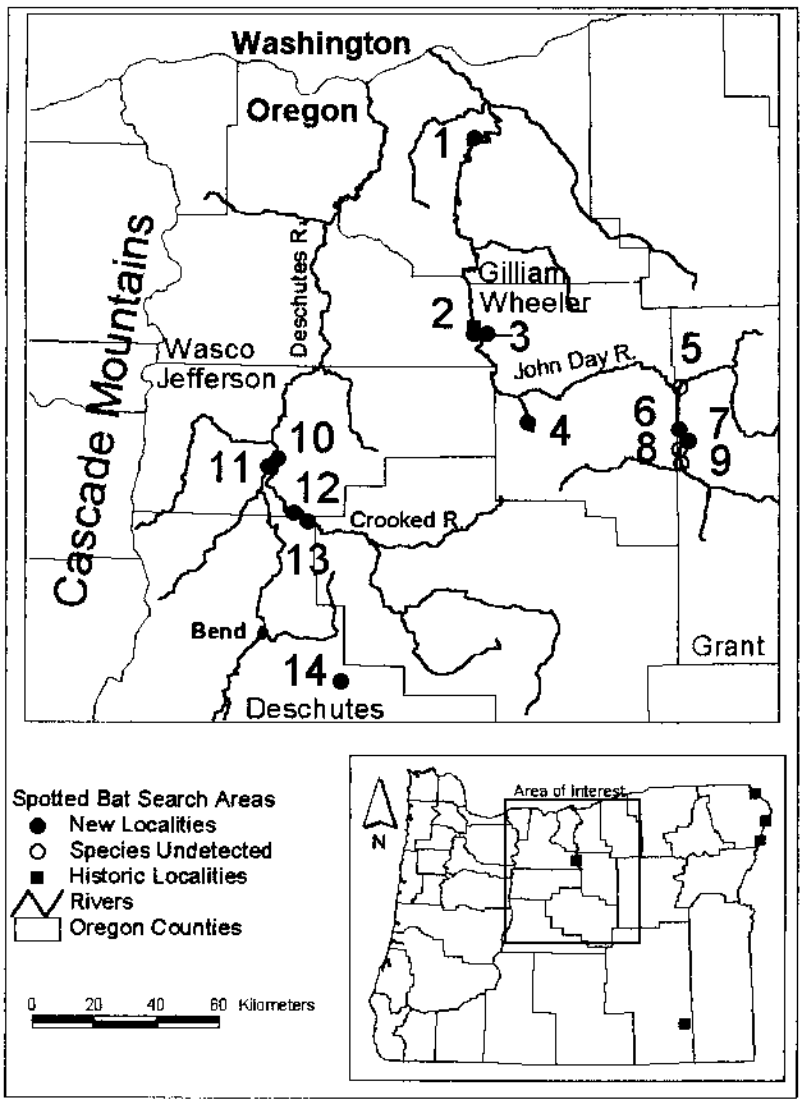


Fig. 1. Search areas included in the 2002–2003 survey of spotted bats in central Oregon. Search area numbers correspond with those listed in Table 1. The inset map shows historic spotted bat localities in the state of Oregon.

individuals was determined by illuminating >1 bat simultaneously, by observing a passing bat at the same time a captured bat was still in hand, and by hearing calls in clearly distinguishable directions. Foraging height estimates were aided by comparing flying height of illuminated bats to the tops of nearby visible structures such as telephone poles and treetops.

An Anabat bat echolocation recording and analysis system (Titley Electronics, Ballina, NSW, Australia; Corben Scientific, Rohnert Park, CA, USA) was used to record spotted bat calls and supplement audiovisual observations. This tool was useful primarily as a means of aiding in species identification and providing a vouchering system. Recordings were also made of calls produced by hand-released spotted bats captured late in the project.

Mist-nets were employed throughout the project both to complete the goals of the NPS inventory and to try to specifically capture spotted bats for this project. Spotted bats are difficult to capture in many areas (Navo et al.

TABLE 1. Search areas included in the 2002–2003 survey of spotted bats in central Oregon. Names are based on the nearest significant geographic feature. Location coordinates are provided in the Universal Transverse Mercator (UTM) projection, using the North American Datum of 1927 (NAD27). Grant County locations are in UTM Zone 11; all others are in zone 10. The detection column refers to the detection method used, where A indicates audible, V indicates visual, R indicates recording, and C indicates capture. The area number corresponds to numbers used in Figure 1. The abbreviation JDFBNM is used for the John Day Fossil Beds National Monument.

| Area # | County | Name | UTM X | UTM Y | Detection |
|---|---|---|---|---|---|
| 1 | Gilliam | J.S. Burres State Park | 697960 | 5038845 | A |
| 2 | Wasco/Wheeler | Clarno | 699850 | 4976410 | A,V,R,C |
| 3 | Wheeler | Pine Creek | 703965 | 4976114 | A,V,R |
| 4 | Wheeler | Bridge Creek, JDFBNM | 718039 | 4948023 | A,V |
| 5 | Grant | Kimberly | 291203 | 4959041 | None |
| 6 | Grant | Cathedral Rock, JDFBNM | 290690 | 4945426 | A |
| 7 | Grant | Big Basin | 293551 | 4941486 | A,V,C |
| 8 | Grant | Goose Rock, JDFBNM | 290113 | 4939115 | None |
| 9 | Grant | Picture Gorge, JDFBNM | 290556 | 4934514 | None |
| 10 | Jefferson | The Cove Palisades State Park | 638427 | 4934143 | A, V |
| 11 | Jefferson | Lake Billy Chinook | 635424 | 4931695 | A |
| 12 | Jefferson | P.S. Ogden Scenic State Wayside | 643950 | 4916520 | A,V |
| 13 | Deschutes | Smith Rocks State Park | 648365 | 4914226 | A,V |
| 14 | Deschutes | Dry River | 660697 | 4863341 | A |

1992, Gitzen et al. 2001), and extensive effort was made to catch the species in our study area. Mist-nets of various lengths (2.6–18 m) were placed across pools and channels of open water along the John Day River and tributaries, across open fields, across a cave opening, and on top of a cliff. Using aluminum electrical conduit, we elevated nets as high as 4.5 m aboveground to try to intercept high-flying bats.

Radio-transmitters were attached to 2 captured spotted bats. Transmitters weighing 0.51 g (LB-2 model, Holohil, Inc. Guelph, Canada) were attached with Skin-Bond surgical adhesive (Smith and Nephew, Ltd., Largo, FL, USA) to the intra-scapular region of the bats. Transmitters weighed less than 5% of the mass of instrumented bats. Bats were tracked using receivers with omni-directional magnetic vehicle roof antennas and 5-element hand-held directional antennas (Wildlife Materials, Inc, Carbondale, IL). The University of Idaho Animal Care and Use Committee approved all capture and handling procedures used during the study.

## RESULTS

In total, we spent 343 hours of mist-netting, recording, and audiovisual observations during 80 nights. Spotted bats were encountered at 14 of 24 survey sites (58%) in 11 of 14 search areas (78%) on 38 of 80 survey nights (48%). Incidental observations of spotted bats were made on 12 additional nights. A total of 138 spotted bat passes were observed throughout the study. At Pine Creek and Clarno (areas 2, 3), where survey effort was most intense, spotted bats were active during all months of the study, from May through October. Several incidental observations of spotted bats were made along Pine Creek during April 2003. We also found spotted bats repeatedly at Smith Rocks State Park (area 13) in June, August, and September 2003. At all other search areas, spotted bats were encountered only during August–October. The species was found in all 6 Oregon counties where search areas were located. Multiple individuals were found at 5 sites in 4 search areas (areas 2, 4, 13, 14), and repeat observations of multiple individuals were made at 3 of those locations (areas 2, 13). We never confirmed more than 3 individuals at a time.

Two male spotted bats were captured on different nights at 1 location on the John Day River (area 2), and a 3rd individual was captured in a different location along the John Day River (area 7) but escaped from the net before it could be processed. Both male bats were instrumented with radio transmitters during late August and early September 2003, but roosts were not located despite extensive searching. After searching for 4 days and nights, we

Names are based on the
nsverse Mercator (UTM)
UTM Zone 11; all others
adible, V indicates visual,
d in Figure 1. The abbre-

| TM Y | Detection |
|---|---|
| 38845 | A |
| 76410 | A,V,R,C |
| 76114 | A,V,R |
| 48023 | A,V |
| 59041 | None |
| 45426 | A |
| 41486 | A,V,C |
| 39115 | None |
| 34514 | None |
| 34143 | A, V |
| 31695 | A |
| 16520 | A,V |
| 14226 | A,V |
| 53341 | A |

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briefly encountered 1 bat foraging approximately 8 km upriver from the capture site, but we could not relocate it again. The 2nd bat was tracked upriver for several hours after being released but was not relocated on subsequent days and nights.

Spotted bats were active at all hours of the night during the study. The earliest observed flights of the species were recorded at Smith Rocks (area 13) on the Crooked River. There, spotted bats were observed flying within 38 minutes after civil sunset in dusky, low-light conditions. At the Dry River canyon (area 14), spotted bats were first heard 43 minutes after sunset. Along the John Day River, the earliest observation was made in the Clarno area (area 2) 63 minutes after sunset, although spotted bats normally did not arrive there until much later in the evening. As a point of reference, emergence times of western small-footed myotis (*Myotis ciliolabrum*) and pallid bats (*Antrozous pallidus*) tracked to day roosts in the John Day Valley during the same study period averaged 24 minutes and 47 minutes after sunset, respectively. Dawn observations of spotted bats were also made on several occasions, including one made 78 minutes before civil sunrise.

We noted considerable variability in the presence and timing of spotted bats at survey sites. While spotted bats were repeatedly encountered at many sites, the species was never encountered at some locations with seemingly ideal habitat (e.g., large cliffs along rivers; areas 5, 8, 9). One incidental observation made at Cathedral Rock (area 6) was the only detection made at that site, despite 3 other nights of formal surveys conducted there. At 7 sites where spotted bats were encountered at least once, the species was detected in only 25 of 53 visits lasting 1 hour or more. During visits to Smith Rocks (area 13) when observers were in place before sunset, spotted bats were first detected 38 and 39 minutes after sunset. The predictability in the timing of the initial arrival of spotted bats there was not consistent with observations made in other areas. During 2 consecutive visits to 1 site in Pine Creek (area 3), 1st arrival in the 2nd visit occurred 30 minutes after 1st arrival on the previous night, and both 1st arrivals occurred more than 3 hours after sunset. Along Bridge Creek (area 4), we observed 2 spotted bats flying together 4 hours after sunset; no other passes were recorded at that site during 5 additional nights of mist-netting.

Spotted bats were repeatedly encountered foraging high over irrigated fields and old fields, low upland slopes of juniper and sagebrush, and along the rims of cliffs. Estimates of flying height made for 61 passes ranged from 3 m to 50 m, and average flying height was 20 m. No spotted bats were observed coming down to drink, although bats were occasionally observed flying high over water. Likewise, on no occasion did we observe spotted bats flying low enough for standard use of mist-nets to be effective. Only after considerable effort and experimentation with elevated nets were we able to capture the species. The most successful net configuration consisted of four 12-m nets erected on 4.5-m poles placed along the rim of a cliff overlooking the John Day River (area 2). This net arrangement was placed where spotted bats had been previously observed cresting low over the top of the cliff. A 3rd spotted bat was captured in a mist-net placed across the mouth of a large upland cave (area 7). Although this net was not elevated, the cave itself is located in the middle of a steep, cliff-like slope. Spotted bats accounted for only 3 of 548 bat captures (0.5 %) made during 300 hours of netting on 65 nights. However, this rate is much higher when effort includes only the number of hours that elevated nets were employed. Elevated nets were employed for 87 hours on 15 nights, and spotted bats accounted for 2 of 16 bats caught. A total of 14 species of bats were captured during the entire study period, but only 6 species were caught in elevated nets.

## DISCUSSION

Prior to this study, only 1 spotted bat had been captured in Oregon (McMahon et al. 1981). That record and those from Barss and Forbes (1984) and the 3 records from the Snake River (Ormsbee and Risdal 2004) suggested a pattern of random and rare occurrences in the state. A search for spotted bats in eastern Oregon in 1983 failed to document the species, further supporting this perception (Fenton et al. 1987). While the spotted bat has an undetermined conservation status with the Oregon Department of Fish and Wildlife, the Oregon Natural Heritage Program placed the spotted

bat on a list of species at risk of extirpation and peripheral species (Oregon Natural Heritage Program 2001). Our results suggest that spotted bats may be much more common and widespread in Oregon than historic evidence suggests. Spotted bats appear to be well established in the lower Deschutes and John Day basins. The presence of spotted bats at the Dry River canyon southeast of Bend provides evidence that the species may occur widely in drier uplands far from large water bodies as well.

In a recent review of the literature, Luce (2005) also suggested that spotted bats might be more common than historic records indicate. Our study and others (Pierson and Rainey 1998, Geluso 2000) that have specifically searched for spotted bats in suitable habitat have added many new localities in recent years. This may be due to an increasing reliance on audible detections rather than capture results. While some investigators have suggested that spotted bat capture results adequately represent abundance, our results suggest otherwise (Fenton et al. 1983, Berna 1990). Without concerted effort using alternative methods, spotted bats would not have been captured at all in our study area, perhaps leading to the spurious conclusion that the species was absent from the region. Navo et al. (1992) and Gitzen et al. (2001) also reported that the species was difficult to capture. Pierson and Rainey (1998) reported captures from only 4 of 28 new spotted bat localities in California. Geluso (2000) reported multiple captures of spotted bats from some locations in Nevada but reported that the species had not been successfully captured in several other locations where it had been detected acoustically.

Clearly, the high-flying behavior of foraging spotted bats encountered in our study played a significant role in capture difficulty. Navo et al. (1992) regularly observed the species flying 10 m or more aboveground and did not observe the species flying low enough to be caught in mist-nets. Others have reported this behavior as well, and we know of at least 1 other investigator resorting to unusual mist-net tactics similar to ours to catch spotted bats (Jason Williams, Nevada Division of Wildlife, personal communication). In areas where the species has been more easily captured in mist-nets, topography and limited open water may force spotted bats to fly at lower heights or in more discrete flight paths, making them more susceptible to capture (Poche 1981, Geluso 2000).

While we propose that spotted bats may be relatively common in central Oregon, we found night-to-night activity somewhat variable. The species was encountered in 78% of search areas, but on only 48% of survey nights. Spotted bats arrived early and regularly at the Smith Rocks area but were much less predictable along the John Day River. Spotted bats were once considered a late-emerging species, but several studies have demonstrated the species to emerge relatively early (Easterla 1965, Wai-ping and Fenton 1989, Navo et al 1992). Our results are consistent with this, and we believe that perceptions of spotted bat emergence times are influenced by the distance of an observation point to roosts. We interpret our results to suggest that spotted bats were roosting close to our observation points at Smith Rocks State Park and Dry River canyon and much farther away from observations made along the John Day River. In the sites where spotted bats were encountered early, the intervals between passes became longer as the night progressed. These late-night activity patterns resembled those in sites with consistently late first-arrival encounters. It may be that the predictability in spotted bat activity patterns declines as bats fly farther from roosts.

An additional consideration to the issue of variability in the timing and presence of spotted bats at search areas is that of transient bats. It seems likely that at least some of the bats encountered in May, June, and July were roosting locally as "resident" bats. However, the disappearance of the 2 male spotted bats fitted with radio transmitters late in August and September provides some evidence of transience, and this behavior may account for some of the variability observed during the study. It may also account for the single encounters at search areas where multiple surveys were made (areas 4, 6, 7). All encounters at these sites occurred in August and September. Several investigators have hypothesized that spotted bats undertake localized migrations to higher elevations in midsummer and return to lower elevations in late August and September (Poche 1981, Berna 1990, and Geluso 2000). Likewise, Rabe et al. (1998) demonstrated that spotted bats are capable of undertaking long daily movements over 30 km. Very little

additional information is available on this topic, but it may be that spotted bats travel considerable distances in central Oregon between roosting and foraging areas and between summer roosts and winter hibernacula.

Woodsworth et al. (1981) reported remarkable regularity in the arrival, direction, and duration of foraging spotted bats on consecutive nights in southern British Columbia. Several other surveys have successfully relied on short (e.g., ≤20 minutes) observation periods (Fenton et al. 1987, Navo et al. 1992, Pierson and Rainey 1998). Based on our experience in central Oregon, however, surveys may be more effective if longer observation periods are used. While some survey objectives may best be served by many short observations, these also may lead to the conclusion that spotted bats are absent from areas where they actually occur.

Despite our assertion that spotted bats are more common than previously believed in Oregon, the species is certainly much less concentrated and locally abundant than, for example, species of *Myotis* where dozens of individuals can be captured during a single night. We were unable to confirm concentrations of more than 3 individual spotted bats during our study, although this was a conservative estimate. It is entirely plausible that, even as new surveys dramatically increase the number of known spotted bat localities throughout its range, the species will continue to be perceived as rare and require conservation attention. Much needs to be learned about the species before this can be ascertained. We strongly recommend that additional surveys be conducted in Oregon in the many areas of potential habitat that have not yet been searched. Higher-elevation forest habitats in eastern Oregon where open meadows and cliffs are present seem to us to be particularly important areas to investigate. There may also be areas of suitable habitat in the southwestern portion of the state where semiarid conditions extend west of the Cascade Mountains. The discovery of spotted bats in Siskiyou County, California, less than 50 miles from the Oregon border, certainly suggests that this may be worthwhile (Pierson and Rainey 1998). Only after more of the distribution and habitat association gaps have been filled can a meaningful spotted bat conservation status be determined for Oregon.

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